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Meat of Tambaqui from fish farming leads the popular preference when compared to wild specimens (Rondônia - Brasil)

A carne de Tambaqui de piscicultura lidera a preferencia popular quando comparada aos especimes selvagens (Rondônia - Brasil)

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ABSTRACT

The purpose of this paper was evaluate the palatability of the meat of tambaqui of different ages and environments, both from natural and cultivated systems. In order to carry out the consumers' acceptability test concerning the tambaqui meat from different feeding, 14 wild fish and 14 cultivated ones were used, with average weight ranging from 0.8 to 8.5 kg, already killed, cut and fresh. The samples were separated according to the environment (wild and cultivated), stored in thermal box and processed as standard fried ribs. The total of 200 untrained tasters of both genders was consulted, with the intention of finding the common public's opinion. The evaluated items were: flavor, color, smell and texture. The samples from pisciculture obtained better acceptability results regarding young fish's meat (63.5%), and the adult's (78.0%), as compared to the same age groups for the natural environment fish with 49.7% and 61.0% of the total evaluated, respectively. Thus, the sensorial analysis demonstrated a greater preference for cultivated tambaqui's meat, with emphasis on the items flavor and texture, which can be attributed to feeding quality (fish food with 28% of crude protein) and husbandry employed in the farming system

Keywords: sensorial analysis; *Colossoma macropomum*; pisciculture; wild fish.

RESUMO

O objetivo deste trabalho foi avaliar a palatabilidade da carne de tambaqui de diferentes idades e ambientes, natural e de cultivo. Para realizar o teste de aceitabilidade dos consumidores entre as carnes provindas de alimentações distintas, foram utilizados 14 peixes de rio e 14 de cultivo, com pesos médios variando de 0,8 a 8,5 kg, estes já abatidos e submetidos aos cortes, in natura. As amostras foram separadas por ambiente (natural e cultivo), armazenadas em caixa térmica e processadas em forma de costelinhas fritas de maneira padrão. Foram consultados 200 provadores não treinados, de ambos os sexos, com a intenção de alcançar a opinião do público comum, os itens avaliados foram: sabor, cor, odor e textura. As amostras dos peixes de piscicultura obtiveram melhores resultados na aceitabilidade das carnes dos peixes jovens 63,5%

e adultos (78,0%), em comparação aos mesmos grupos de idades para os peixes de ambiente natural com 49,7% e 61,0% do total avaliado, respectivamente. Dessa forma, a análise sensorial mostrou maior preferência pela carne do tambaqui de cultivo, com destaque para os itens sabor e textura, o que podem ser atribuídos a qualidade alimentar (ração com 28% de proteína bruta) e ao manejo empregados nos sistemas de criação.

Palavras-chave: Analise sensorial; *Colossoma macropomum*, piscicultura; peixe selvagem.

1 INTRODUCTION

Pisciculture is a relevant activity that has been growing in Brazil (FAO, 2010), contributing with approximately 71% of the total production value of aquatic organisms (IBGE, 2016). The national fish production originated from pisciculture has increased and the estimated projections show that such growth may surpass 100% by the year 2025 (FAO, 2016a), which aids in the world demand for quality food, thus improving in nutritional, social, economic and environmental aspects.

Concerning the environment, fish farming has indirectly cooperated to preserve the natural stocks of fish, once the increase in fish production divides the interest in fishing resources from wild and cultivated environments. However, the first group has shown stagnation and even a qualitative decline in its stocks throughout the years (SUFRAMA, 2003; FAO, 2010). Over the last few decades, many wild fish stocks are overfished due the lack of management. Such problem has been getting worse mainly in the states of the North Brazil, where fish meat is the favorite food in many urban centers (Menezes et al., 2008). On the other hand, this demand for fish also favors its production in captivity in that region (FAO, 2003), which is reflected in pisciculture, whose growth has been fast in the entire Amazon basin (Gonçalves, 2007).

The main species cultivated in the Northern Brazil is the tambaqui (*Colossoma macropomum*, Cuvier 1818), with a total production of about 106 thousand tons in 2014, to which the state of Rondônia contributed with 70.20% (IBGE, 2014). *C. macropomum* is an endemic species to the basins of the Amazon and Orinoco Rivers, and it is the second largest freshwater scale fish in that region (Garcez and Freitas, 2011).

Tambaqui is among the most consumed fish, not only in the North Region, but also throughout Brazil, due to the quality of its meat with high nutritional value having conquered the consumer market with its flavor and healthy properties (Barçante and Sousa, 2015). As a viable source of omega, and considered to be a noble product in the market (Gomes et al.,

2003), it has a great potential for exportation. Nevertheless, some obstacles are still found in cultivating this species, such as the difference in flavor between the cultivated fish and those caught in the natural environment.

There are reports about cultivated fish that not presenting meat as tasty as those from wild environments (Reque et al., 2010). Even among fishermen and fish farmers, it is believed that the wild tambaqui flavor quality would be better, when compared to the individuals cultivated in pisciculture. Such difference may result from the food diet of the cultivated fish (Matthiesen and Quadros, 2012), as the tambaqui has omnivorous habits, consuming fruits and seeds of the flooded forest, which are among the main products influencing in the flavor of fish meat that coming from the river (Gomes et al., 2003). On the other hand, fish produced in captivity are fed based on a balanced diet, offered as industrialized fish food (Fernandes et al., 2018). Furthermore, the meat of fish raised in captivity, when not managed appropriately, often presents a mud off-flavor, perceived both by flavor and smell (Kubitza, 1999).

The preference for consuming certain type of food is an individual option, related to socioeconomic condition, health condition, and cultural tradition (Jomori et al., 2008). These factors may present a similarity in preferences when referring to groups of people living in the same region and adopting eating habits, as is the case of the amazon population (MPA, 2013). In this sense, the preference for one of the different groups of fish (wild or cultivated tambaquis) may be indicated more easily by the population itself (Sakabe et al., 2013). The acceptability of meat of cultivated tambaqui in a region that already is adequated to its flavor may set an increase in local demand and, consequently, make standardizing easier for the international market to be served.

In order to assess the level of acceptance of meat of cultivated tambaqui in relation to market demand, it is necessary to carry out studies involving sensorial analysis, so as to understand the levels of acceptability of this food by the final consumer, and increase its industrialization potential (Madsen et al., 1996). For this purpose, the application of organoleptic tests is indispensable, making use of the human senses, as the flavor, sight, smell and touch (Teixeira, 2009), as well as statistical analyses (Granato et al., 2014), so that the degree of acceptability of meat of tambaquis fished from different environments, wild and cultivated, may be compared (Teodoro et al., 2007). Hence, this issue (speculations) may be solved for the consumer market, as the information and researches on this theme are incipient. Therefore, this research focused on testing the hypothesis that the meat of young and adult

tambaquis coming from both wild and cultivated environments don't differ significantly between one another in their organoleptic properties.

2 MATERIAL AND METHODS

2.1 FIELD OF STUDY

This study was carried out in the state of Rondônia, as it is the largest producer of cultivated tambaquis in Brazil (PEIXE BR, 2019). The areas where the fish were collected and the sensorial analyses were conducted including three municipalities: Ji-Paraná (10°52'37,40"S and 61°57'06,45"W), Presidente Médici (11°3'43.90"S and 61°53'55.93"W), and Costa Marques (12°26'42,33"S and 64°13'37,20''W). The cultivated tambaquis were collected in the municipality of Presidente Médici, in the Machado River basin, as it is a region with the largest fish farm production in the state, whereas the wild fishes were collected in Costa Marques, in the Guaporé River basin (Figure 1).

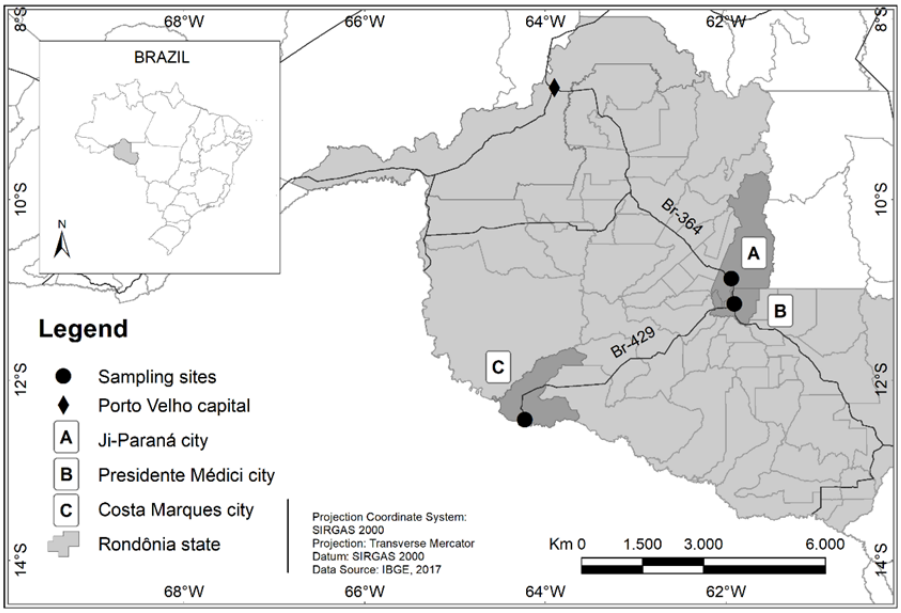

Figure 1 – Sampling sites where the tambaqui were caught (B = cultivated fish and C = wild fish) and the locations where the sensorial analysis was carried out (A and C).

2.2 COLLECTION AND DATA PREPARATION

The tambaqui samples were acquired in October 2018 (young fish, 14 specimens weighing from 0.8 to 1.5 kg) and June 2019 (adult fish, 14 specimens weighing from 3.4 to 8.5 kg). The tambaqui from fish farming were obtained from a pisciculture near the city of

Presidente Médici; their feeding consisted of fish food with 28% crude protein. As for those wild fish caught in the river, they were obtained from local fishermen in the city of Costa Marques. For the collection of wild fish, the fishing license number 65059-2, issued by the Instituto Chico Mendes de Conservação da Biodiversidade – ICMBio was used. This paper was approved by the Research Ethics Committee of the Universidade Federal de Rondônia with registry number 82882817.5.0000.5300.

The fish selected for this study were acquired already dead. The sampled tambaqui were identified, wrapped and packed with ice in a thermal box. Afterwards, the specimens were transported to an adequate place where they were weighed (g), cleaned (eviscerated, washed and skinned) and applied in preparing the samples, being cut in the form of rib snacks. The tambaqui lots were divided in two groups (wild fish from river environment - sample 1; and, cultivated - sample 2). Moreover, the fish were separated in groups of young and adult individuals.

After the separation of the groups and processing of the fish, the ribs were dry fried in separate electric fryers, of the Air Fry type (3.2 liters), at a temperature of 160° C, for 20 minutes, considering the separation of fish lots by age and environment (wild and cultivated fish). The temperature was monitored through a thermostat attached to the fryer. The ribs were not salty, in order to do not interfere with the flavor of the fish meat. After being fried, the samples were wrapped in aluminum shelter, labeled accordingly and stored in isothermal boxes to preserve its temperature until the time of the organoleptic valuation.

Afterwards, in order to compose the judging board (tasters), 200 people were randomly chosen (they were not identified in any way, so the participants' identity was kept secret). A sample number of 100 judges were interviewed in the fishing village and in the municipal fair in the city of Costa Marques, where the young's fish meat was analyzed (in 2018). The same procedure was employed for the samples of adult fish meat, examined in the sensorial analysis with the people from the fishing village and the ones passerby in the municipal fair of the city of Ji-Paraná (N = 100 taster, in 2019).

All the participants tried a rib from each lot, making their sensorial valuation for the items: flavor, color, smell and texture, reported in a table printed for this purpose. For such assessment, each taster evaluated the product (ribs) considering a grade from 0 to 10, according with the following value scale: very bad (VB = 0 to 2); bad (B = 3 to 4); good (G = 5 to 6); very good (VG = 7 to 8); and, excellent (E = 9 to 10). Between each sample assessment (sample 1 and sample 2), the taster was asked to wash their mouth with water, to avoid the

sample characteristics to interfere with each other. The information obtained was placed in electronic charts for later statistical analyses.

2.3 STATISTICAL DATA ANALYSIS

Firstly, the values of the wild and cultivated tambaqui meat from organoleptic samples were submitted to the Levene and the Shapiro-Wilk tests to verify the assumptions for homoscedasticity and normality, respectively. Posteriorly, the data were submitted to the Student's *t*-test ($\alpha = 0.05$), which were placed in a chart to verify the significant differences between the variables in the sensorial analysis (flavor, color, smell and texture), for the different fish groups (wild and cultivated) and age (young and adult).

Furthermore, to evaluate the similarity strength of the coordinates between the organoleptic variables of tambaqui meat of distinct age and environment and with the consumer's preference evaluation grades according to the different typed of tambaqui meat, a Correspondence Analysis was employed to clarify the data distributed through the components projected on the axes x (dimension 1) and y (dimension 2) in a graph. Following this, the relative frequency values by sensorial variable analyzed were determined in percentages to attribute an evaluation. All the statistical analyses were performed using the software Statistic 9.0 (STATSOFT, 2009), opting for the probability inferior to p-value = 0.05 to reject the null hypothesis (Conagin et al. 2008).

3 RESULTS

During the study, 200 sensorial analysis tests were applied for the organoleptic assessment between the meat of young and adult, wild and cultivated tambaqui. The data, when applied in the Student's *t*-test, demonstrated significant differences ($p < 0.05$) between the organoleptic variables of preference for types of meat from the fish groups by age and environment (Table 1). In the group of young tambaqui, they presented significant differences between wild and cultivated fish, particularly for flavor and texture values. On the other hand, for adult fish from the different environments, the sensorial values presented significant differences between all the organoleptic parameters assessed (Table 1).

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Table 1 - Student's *t*-test for paired samples, between the sensorial variables of the tambaqui meat, by age and between the wild and cultivated individuals. The values were significant when $p < 0.05$.

Wild tambaqui		Cultivated tambaqui					
		Flavor	Color	Smell	Texture	*t*-value	N
Young fish	Flavor	0.008				-2.6659	100
	Color		0.210			-1.2553	100
	Smell			0.046		-2.0015	100
	Texture				0.028	-2.2056	100
Adult fish	Flavor	0.001				-4.1155	100
	Color		0.005			-2.7983	100
	Smell			0.001		-3.6364	100
	Texture				0.012	-2.5106	100

N = number of paired samples applied in the analysis.

The multivariate exploratory technique explained with 86.81% the data ordering through the Correspondence Analysis between the relation of the data projected on the axes of factors 1 (inertia of 58.05%), where the sensorial variables and their assessment scores were grouped, belonging to the different lots: wild tambaquis on the left side, and cultivated ones on the right of the graph (Figure 2). On axe 2 (inertia of 28.76%), the young fish were grouped on the upper half (the grade VB tending to be linked to the parameters texture, smell and flavor), and the adults on the lower half of the graph (they grades B and VG linked to the variables smell, color and flavor). The sensorial parameters for the young and adult cultivated fish meat were placed on the right upper portion of the dimensional frame, represented with the grade E linked to smell, texture, color and flavor characteristics (Figure 2).

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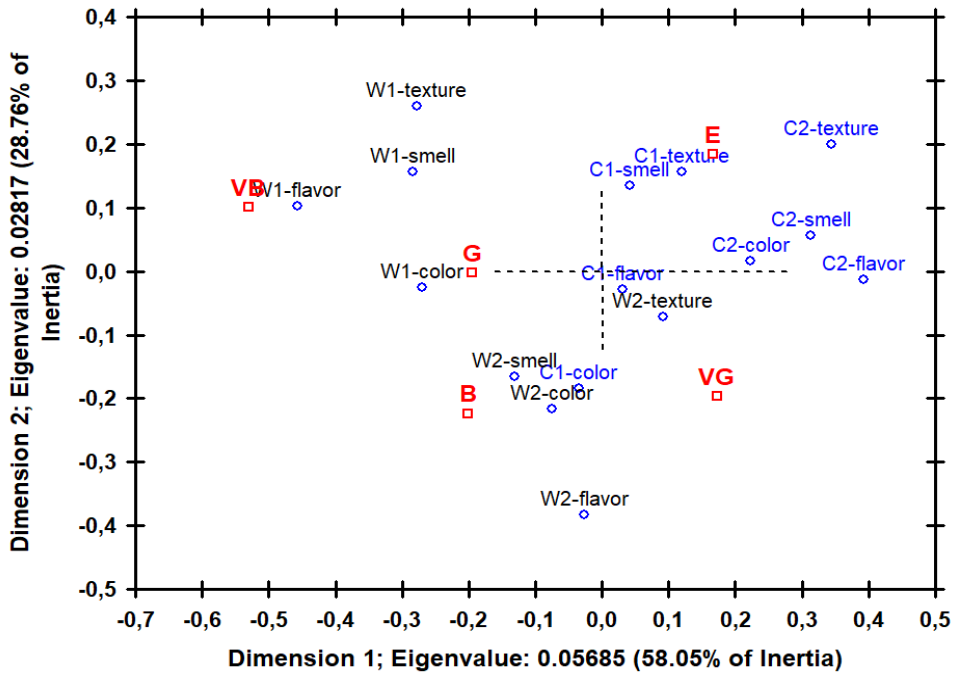

Figure 2. Correspondence Analysis showing the distribution of score for sensorial variables and values attributed to the preferences between the meat of the different tambaqui groups evaluated (color, smell, flavor and texture), in which: 1 = young fish; 2 = adult fish; W = wild; C = cultivated. Scoring scale: VB = very bad (0 to 2); B = bad (3 to 4); G = good (5 to 6); VG = very good (7 to 8); and, E = excellent (9 to 10).

The relative frequency values of the organoleptic parameters linked to the summation of the grouped grades (VB + B, and VG + E) of the young and adult fish lots by environment also separated the groups of wild and cultivated tambaquis, exhibiting greater consumers' preference for the cultivated tambaqui meat. In such, the young wild fish had the greatest rejection, with 28.25%, when compared to the cultivated specimens, with 17.2%; the acceptability of these cultivated specimens' meat was of 49.7% and 63.5%, respectively. Similar results were presented between the groups of adult fish, with greater rejection of wild specimens' meat (22.0%), and minor to the cultivated ones (9.0%); it was followed by acceptability of 61.0% and 78.0%, simultaneously.

4 DISCUSSION

The consumption of fish is not frequent in all the regions of Brazil; there is unfamiliarity on the part of the population regarding the importance of fish meat in the human diet. Hence, there is not a national preference for fish, either cultivated or natural environment ones (Lopes et al., 2016); such eating preference is thus connected to other types of meat. In this study, the results of the sensorial analyses attributed preferences for cultivated tambaqui

meat, especially regarding flavor and texture, with values superior to those presented by the wild tambaqui meat. These findings are not in agreement with the frequent results found in the existing literature, in which the organoleptic standards of fish in the wild environment, most of the times, seem to be superior to the cultivated ones (Sylvia et al., 1995; Postel et al., 1996; Farmer et al., 2000; Grigorakis et al., 2003).

When considering young and adult tambaquis, the results of the organoleptic tests presented by the adult cultivated fish, as compared to adult wild ones, had great distinction, with better results for the first group. As for the young cultivated and young wild fish, though the cultivated fish meat were assessed as having a better quality, in the color parameter there were no differences, and regarding smell, the differences were marginal. The smaller individuals, in their development stage, may be less affected concerning the two abovementioned parameters, not incorporating in its meat aspects that would contribute to its rejection (Sone and Nortvedt, 2009).

The greater acceptability of cultivated tambaqui meat may be related to the type of feeding and husbandry employed while they are being raised. In the past few years, technological advancements made the introduction of new production techniques possible, with affordable costs and significant productivity and quality gains, providing improvements for fish farming (Siqueira et al., 2018), in addition to fish food being produced with raw material of better quality, reflecting on the higher quality of the fish meat (Andrés-Bello et al., 2013).

This fact is evidenced when the fish farming industry of the state of Rondônia is analyzed, which is one of the fastest growing ones in Brazil, having become the region of greatest production of native fish species in the country (PEIXE BR, 2019). This has resulted in increase in investments on researches for the improvement of fish food quality, both by the government and private industries (Kubitza, 2015). Furthermore, the combination of fish food quality and appropriate husbandry mitigate one of the major complaints related to cultivated fish, which is its off-flavor, i.e., when the meat has a disagreeable flavor and smell as a consequence of substances (e.g., geosmin and methylisoborneol) produced by cyanobacteria present in the water of the fishponds, or compounds with which the fish food residuals is produced (Bombardelli et al., 2005).

In contrast, the environmental degradation resulting from anthropic actions in the state of Rondônia (Pagani and Maniesi, 2019) may be contributing to the decrease in diversity of food items from the riparian forests, while studies demonstrate that the more diverse is the

feeding of animals, the higher is the quality of their meat (Powell et al., 2015). The hygienic quality of the fishing products in Brazil is still incipient, influenced by environmental factors, such as pollution of aquatic environments, which increases the diversity of microbiota found in fish, including pathogenic species (Farias and Freitas, 2008; Rocha et al., 2013). These factors may have influenced the low acceptability of wild tambaqui meat in this study.

In terms of body composition, when considering, for instance, fatty acids, it may present differences between categories of wild and cultivated fish (Afkhami et al., 2012). In this research, the chemical composition of the fish was not analyzed; however, studies report that diets with different types of vegetable and animal oil may influence the body composition of the *C. macropomum* even in controlled environments, as pisciculture (Pereira et al., 2018). Therefore, it is necessary to establish a husbandry standard for the fish to present higher quality and similar organoleptic characteristics for the consumer market. In this regard, sensorial tests in fish meat have been important tools to verify the quality (Oliveira et al., 2014) and acceptability of this product by the final consumer (Teixeira, 2009).

Throughout the last decades, the consumption of fish has been presenting a tendency to grow, with an annual increase of 2.3% *per capita*, though still below the recommended by the Food and Agriculture Organization of the United Nations (FAO, 2018). Eating fish is directly related to cultural issues and, mainly, to availability, which is evidenced when the regions of Brazil are individually analyzed, as the preference for fish is not homogeneous. The North Region is the one with greatest preference for this product, above all due to the great availability of aquatic environments that make fishing and fish farming possible (Lopes et al., 2016), so that the continuous offer of this food product facilitates the ascension of the region's fishing and fish farming industries (SUFRAMA, 2003; Oliveira et al., 2007).

The fish supply by means of aquiculture has reached the same level of the extractivist fish production (FAO, 2018), thus becoming a positive factor for the decrease even of overfishing in natural environments (Moreno, 2019). On the other hand, the search for fish from natural environments has been gradually decreasing (Moreno, 2019), which may be related to countless environmental problems as deforestation (Castello and Macedo, 2016), construction of hydroelectric power plants (Magalhães et al., 2016), and pollution of rivers and streams (Dellamatrice and Monteiro, 2014), which has been negatively affecting the aquatic environments (Val, 2019).

These factors have been motivating the consumer to search for fish more often in the fish farms, where the fish is expected to be found healthier and with higher nutritional value

in its meat (Bombardelli et al., 2005). The increase in the scientific search for fish production has been motivating fish farmers to perfect their raising methods, aiming to improve the quality of protein in the fish meat, including all strategies to develop an ideal balanced diet to be offered to the animals as they are raised (Soares and Gonçalves, 2012).

Hence, the results presented here indicate that cultivated tambaqui meat had a higher acceptability by the final consumer, when compared to wild tambaqui meat, which may be attributed to husbandry and to the access to food available to the animals in the different environments.

5 CONCLUSION

The use of sensorial tests and analyses applied to the meat of wild and cultivated tambaquis indicated that there are significant organoleptic differences between the groups of fish assessed. The results demonstrated that most of the consumers opted for cultivated tambaqui meat, as it presented better quality regarding flavor and texture. Such factors may be related to the feeding and husbandry quality employed in the raising system.

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